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ABSTRACT

From the statewide assessment of mathematics performance conducted by the Minnesota Department of Education, specific study findings for 17-year-olds attending public and nonpublic schools included demographic data and information on student attitudes toward education programs and mathematics, and mathematics achievement. Data analyses suggested that students with no vocational education courses performed better in areas of higher mathematical concepts but that students with the most vocational education scored higher in practical applications of mathematical skills. The expectation that students in career and vocational education mathematics activities would acquire mathematical skills relevant to the world of work appeared confirmed. The major recommendation was that vocational educators should formulate mathematics objectives for their students so that a specific prediction of achievement differences might be tested. This project report includes 10 data tables including one that summarizes the findings. (MF)

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ED137541

FINAL REPORT

PROJECT NO. 7-D-75

# STATEWIDE MATHEMATICS PERFORMANCE RELATED TO CAREER AND VOCATIONAL EDUCATION

Research and Development Project
in Career Education

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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August, 1976



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# PREFACE

During the 1974-75 school year a statewide assessment of mathematics performance was conducted as part of the Minnesota Education Assessment Program. This effort was conducted by the office of Statewide Educational Assessment, Minnesota Department of Education.

Because of the implecation for vocational education, the Division of Vocational-Technical Education provided support for that part of the study involving 17-year-old students. The report which follows describes the findings of that study as they pertain to the mathematics performance of students in vocational education.

## SUMMARY OF THE REPORT

This report is derived from state-wide mathematics assessment results regarding mathematics performance of approximately 16,000 17-year-olds attending Minnesota public and nonpublic schools. In addition to student performance on mathematics items, data on students, school and district characteristics were collected to determine their relationship to mathematics performance. The present report is specifically concerned with the characteristics of vocational education students as derived from program, school and district data; and the relationship between these characteristics and mathematics achievement measured during the 1974-75 school year.

### I. Deomographic Data

Approximately 62 percent of all 17-year-old students participating in the study had some vocational educatior courses, with slightly less than half of these participating in one year or less of courses. Participants were balanced in terms of gender at all levels of vocational education: 11 percent of males and 12 percent of females had participated in the maximal number of courses.

Students who participate in several vocational education courses (2½-3 years in grades ten through twelve) were

found to have career aspirations similar to those of students with no vocational education, i.e., showed in favor of the professions, but a higher percentage (38 versus 25) aspire to a skilled occupation. Interestingly, this increase appears to be due to fewer students with vocational education training wanting semi-skilled jobs as well as a slight decrease in the percentage aspiring to professional levels.

Vocational education students were distributed geographically in a somewhat different pattern than were students with no vocational education. The latter tend to be predominantly from suburban schools (42 percent), although there were also large numbers in small city and rural schools (37 percent), while the majority of the former were from small city and rural schools (57 percent). Large and medium city schools had approximately equal representation among nonvocational education and vocational education students. Students at all levels of vocational education were distributed by socioeconomic status in approximately the same form, although a lower percentage of students with one and one-half or more years of vocational education were from the highest SES level than were students with one year or less of vocational education.

## II. Attitudes of 17-year-olds

Attitudes toward mathematics may be investigated in several ways. The most direct way, and the one used in this study, was to query students regarding their attitudes.

Approximately half of the students with no vocational education expressed a liking of mathematics. This percentage remains stable with increasing number of vocational education courses taken. Further, the proportion of students indicating they disliked mathematics was similar for those having no vocational education (14 percent) and those having taken the greatest amounts of vocational education (13 percent).

As attitudes toward mathematics appear to be highly related to the number of mathematics courses taken (without speculating as to the direction of causality), the number of mathematics courses may also be inspected. Again, the distributions for years in mathematics were nearly identical at different levels of vocational education. If there was any perceptible change, it was that fewer students with the largest amounts of vocational education had little or no (one year or less) high school mathematics (11 percent) versus 18 percent of students with no vocational education.

## III Mathematics Achievement

The crucial questions asked here were:

1. how do students at varying levels of vocational education perform;
2. were there differences in performance as a function of type of program, and
3. were there different patterns of achievement within the mathematics assessment for vocational education and nonvocational education students?

A. Overall performance: As indicated by the following information, the comparisons of total mathematics performance for vocational and nonvocational students was not conclusive.

Number of Years in Vocational-Technical Courses

| | Mean Percent Correct |
|---|---|
| None | 52.3% |
| ½ to 1 year | 53.3 |
| 1½ to 2 years | 53.9 |
| 2½ to 3 years | 53.6 |

B. Performance by Program Area: Mean performance by students in various vocational education programs does not appear to differ significantly from the state-wide mean of 53 percent, particularly with lower numbers of vocational education courses taken. Students in agribusiness and marketing/distribution programs scored slightly below the mean (49.6 percent) while students in business and office and technical programs scored slightly above the mean (54.5 percent and 55.6 percent, respectively). Some interaction between type of program and number of courses taken may, however, occur: the achievement of home economics students

with 3-4 courses declines to 46.2 percent, and to 43.4 percent with five or more courses. The effect of amount of vocational education is explored below.

C. Number of Vocational Education Courses: While there is some suggestion that performance may decline in some programs with increased numbers of courses, a more detailed analysis in terms of clusters of items and particular objectives suggests that with increasing numbers of vocational education courses, there may be a decline in some areas of mathematics achievement but an increase in others.

Generally, it appears that there are areas of mathematics in which students with no vocational education perform better (quadratics; graphing functions; finding equation of a graph) and related areas in which students with the most vocational education perform significantly below the state mean (knowledge of trigonometric terms, identifying a graph of a function, involving simultaneous equations, expanding binomials, and finding equation of a graph). However, on a set of objectives which can be characterized as practical applications of mathematical skills, students with the most vocational education courses scored significantly better than the group as a whole. Included in this set were knowledge

of basic operations, computational skills, interpolating and extrapolating from a table, solving verbal problems, applying formulas, and comparative buying. The analysis of objectives suggest that vocational education students, though they may be exposed to fewer higher level mathematical concepts, are proficient in making practical application of their mathematical skills.

## BODY OF THE REPORT

A. Problem: One of the concerns of those involved in vocational education is the impact of career and vocational education courses on the basic skills of student participants. In particular, the present study was undertaken to assess the effects of vocational education participation on the mathematics achievement of Minnesota 17-year-olds and to identify in-school variables related to mathematics achievement and attitudes of students who have not been enrolled in formal mathematics courses. Very little data relevant to this concern has been collected to date, despite the increasing demand for greater career relevancy in the secondary school curriculum.

B. Goals and Objectives: The objectives of the present study parallel those developed for the Minnesota Education Assessment Program (MEAP), adapted to consider mathematics achievement and in-school variables related to vocational education:

1. To determine the level of performance of 17-year-old students in Minnestoa in various aspects of mathematics;
2. To delineate the attitudes toward educational programs and mathematics education of Minnesota 17-year-olds;

3. To identify the variables which account for the variation in student achievement and attitudes[1];
4. To report the results to educational decision-makers.

C. Description: Through mathematics related activities in career and vocational education there is an expectation that students will acquire competency and skills in mathematics which are relevant to the world of work. Therefore, this study sought to identify, through a survey of 16,000 in-school 17-year-olds randomly selected throughout Minnesota, the program characteristics associated with mathematics performance. The survey was conducted as part of a comprehensive MEAP which conducted a state-wide study of mathematics achievement of 17-year-olds in 1975.

Copies of the assessment instruments and survey materials used in this study may be found in Appendix 1. Where relevant, statistical tests of mean performance difference (t) were computed between distributional groups on each in-school variable.

[1] The primary variables explored in the current study are those directly related to vocational education participation or derived from it.

D. Results: With an increasing demand for career orientation in the secondary school curriculum, and with an increasing response to that demand in expanded vocational education curricula, some important questions may be raised regarding vocational education programs. The basic questions around which the data of this report may be organized are:

1. who are the students serviced by vocational education;
2. what relationship does vocational education have with students' attitudes toward schooling, and, as the particular emphasis of this report, toward mathematics; and
3. what are the mathematical abilities (achievement) of vocational education students so compared to state-wide norms.

Answers to these questions were sought by including inventory items in the student questionnaire of Minnesota State-Wide Educational Assessment of 17-year-old mathematics performance and examining relationships between questionnaire responses and mathematical performance.

1. Demographic Data

Table 1 displays percentages of 17-year-olds in nine cross-tabulated categories. Approximately 62 percent of all students have had some vocational education courses, with slightly less than half of these participating in one year or less of courses. Participants were balanced in terms of gender at all levels of vocational education: 11 percent of males and 12 percent of females have participated in the maximal number of courses.

Students who participate in several vocational education courses (2½ - 3 years) have career aspirations generally similar to students with no vocational education but a higher percentage (38 versus 25) aspire to a skilled occupation.

TABLE 1

PERCENTAGE OF SEVENTEEN-YEAR-OLDS IN EACH CATEGORY

MATHEMATICS ASSESSMENT, 1975

| | | SEX | | CAREER ASPIRATIONS | | | ATTITUDE TOWARD MATH | | | YEARS IN MATHEMATICS | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Male | Female | Semi-skilled | Skilled | Professional | Dislike it | It's O.K. | Like it | None | ½ - 1 | 1½ - 2 | 2½ - 3 | 3½ or more |
| SEX | Male | | | 43 | 49 | 50 | 58 | 53 | 41 | 63 | 46 | 42 | 51 | 64 |
| | Female | | | 57 | 50 | 49 | 41 | 46 | 58 | 35 | 53 | 58 | 49 | 36 |
| CAREER ASPIRATION | Semi-skilled, etc., | 7 | 9 | | | | 15 | 10 | 4 | 14 | 16 | 10 | 4 | 2 |
| | Skilled | 30 | 29 | | | | 29 | 35 | 25 | 24 | 37 | 36 | 24 | 16 |
| | Professional, etc | 53 | 50 | | | | 39 | 43 | 63 | 38 | 32 | 43 | 63 | 74 |
| ATTITUDE TOWARD MATHEMATICS | Dislike it | 14 | 10 | 23 | 12 | 9 | | | | 41 | 20 | 13 | 8 | 7 |
| | It's O.K. | 45 | 37 | 52 | 48 | 34 | | | | 39 | 50 | 45 | 37 | 30 |
| | Like it | 40 | 53 | 25 | 40 | 57 | | | | 18 | 30 | 41 | 55 | 63 |
| YEARS IN MATHEMATICS | None | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 0 | | | | | |
| | ½ - 1 | 15 | 16 | 32 | 20 | 10 | 26 | 19 | 10 | | | | | |
| | 1½ - 2 | 32 | 42 | 45 | 44 | 31 | 41 | 41 | 33 | | | | | |
| | 2½ - 3 | 36 | 33 | 19 | 28 | 42 | 24 | 31 | 41 | | | | | |
| | 3½ or more | 15 | 8 | 2 | 6 | 17 | 7 | 8 | 16 | | | | | |
| YEARS IN VOCATIONAL/ TECHNICAL EDUCATION | None | 38 | 38 | 42 | 32 | 39 | 43 | 37 | 37 | 63 | 42 | 37 | 37 | 36 |
| | ½ - 1 | 28 | 26 | 27 | 26 | 28 | 26 | 28 | 27 | 17 | 29 | 26 | 27 | 27 |
| | 1½ - 2 | 22 | 24 | 20 | 26 | 23 | 19 | 24 | 24 | 10 | 21 | 24 | 24 | 24 |
| | 2½ - 3 | 11 | 12 | 11 | 15 | 10 | 12 | 11 | 12 | 3 | 8 | 12 | 12 | 13 |
| ADJUSTED MAINTENANCE COST/PUPIL | ≤$ 725 | 14 | 13 | 18 | 15 | 12 | 14 | 15 | 12 | 6 | 17 | 15 | 12 | 11 |
| | $726-890 | 42 | 41 | 44 | 44 | 45 | 43 | 43 | 40 | 42 | 45 | 44 | 39 | 37 |
| | >$890 | 36 | 36 | 31 | 34 | 38 | 35 | 35 | 37 | 49 | 33 | 32 | 39 | 42 |
| SIZE OF COMMUNITY | Large City | 12 | 16 | 11 | 14 | 14 | 12 | 14 | 15 | 17 | 10 | 13 | 15 | 16 |
| | Suburban | 32 | 30 | 25 | 27 | 34 | 34 | 29 | 32 | 38 | 23 | 31 | 34 | 33 |
| | Medium City | 9 | 9 | 8 | 7 | 9 | 7 | 8 | 10 | 10 | 8 | 9 | 9 | 9 |
| | Small City/Rura | 47 | 46 | 56 | 51 | 42 | 46 | 49 | 43 | 35 | 59 | 47 | 42 | 41 |
| PUPIL SOCIO-ECONOMIC STATUS | Low | 19 | 21 | 37 | 25 | 14 | 24 | 23 | 17 | 15 | 29 | 23 | 16 | 13 |
| | Middle | 58 | 57 | 54 | 64 | 55 | 57 | 59 | 57 | 62 | 60 | 60 | 56 | 53 |
| | High | | | | | | | | | | | | | |
| USE OF CALCULATOR OR COMPUTER | Neither | | | | | | | | | | | | | |
| | Calculator only | | | | | | | | | | | | | |
| | Computer only | | | | | | | | | | | | | |
| | Both | | | | | | | | | | | | | |

TABLE 1 (Continued)

| | | PUPIL SOCIO-ECONOMIC STATUS | | | USE OF CALCULATOR OR COMPUTER | | | |
|---|---|---|---|---|---|---|---|---|
| | | LOW | MIDDLE | HIGH | NEITHER | CALCULATOR ONLY | COMPUTER ONLY | BOTH |
| SEX | MALE | 46 | 49 | 49 | 42 | 47 | 51 | 58 |
| | FEMALE | 54 | 51 | 50 | 56 | 52 | 49 | 41 |
| CAREER ASPIRATION | SEMI-SKILLED, ETC. | 15 | 7 | 3 | 10 | 8 | 6 | 5 |
| | SKILLED | 37 | 33 | 14 | 31 | 31 | 26 | 26 |
| | PROFESSIONAL, ETC. | 36 | 49 | 73 | 45 | 51 | 58 | 60 |
| ATTITUDE TOWARD MATH | DISLIKE IT | 14 | 12 | 10 | 14 | 11 | 12 | 11 |
| | IT'S O.K. | 47 | 42 | 33 | 43 | 40 | 42 | 37 |
| | LIKE IT | 39 | 46 | 56 | 42 | 49 | 46 | 53 |
| YEARS IN MATHEMATICS | NONE | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| | ½ - 1 | 22 | 16 | 8 | 23 | 14 | 11 | 7 |
| | 1½ - 2 | 42 | 38 | 29 | 40 | 36 | 39 | 30 |
| | 2½ - 3 | 27 | 34 | 45 | 28 | 37 | 37 | 43 |
| | 3½ - 4 | 7 | 11 | 18 | 6 | 12 | 12 | 19 |
| YEARS IN VOCATIONAL/ TECHNICAL EDUCATION | NONE | 36 | 36 | 45 | 37 | 37 | 40 | 37 |
| | ½ - 1 | 28 | 27 | 27 | 26 | 28 | 28 | 26 |
| | 1½ - 2 | 24 | 25 | 19 | 22 | 24 | 22 | 2, |
| | 2½ - 3 | 12 | 12 | 8 | 11 | 12 | 11 | .1 |
| ADJUSTED MAINTENANCE COST/PUPIL | ≤$725 | 18 | 14 | 8 | 13 | 15 | 10 | 15 |
| | $726 - 890 | 43 | 44 | 33 | 40 | 44 | 42 | 42 |
| | >$890 | 32 | 33 | 46 | 36 | 33 | 39 | 39 |
| SIZE OF COMMUNITY | LARGE CITY | 15 | 13 | 15 | 15 | 9 | 20 | 13 |
| | SUBURBAN | 20 | 30 | 44 | 28 | 24 | 44 | 37 |
| | MEDIUM CITY | 7 | 8 | 11 | 10 | 10 | 5 | 7 |
| | SMALL CITY/RURAL | 58 | 48 | 30 | 47 | 56 | 32 | 42 |
| PUPIL SOCIO-ECONOMIC STATUS | LOW | | | | 23 | 20 | 18 | 16 |
| | MIDDLE | | | | 57 | 60 | 57 | 56 |
| | HIGH | | | | 18 | 20 | 25 | 28 |
| USE OF CALCULATOR OR COMPUTER | NEITHER | 45 | 39 | 33 | | | | |
| | CALCULATOR ONLY | 24 | 26 | 23 | | | | |
| | COMPUTER ONLY | 12 | 13 | 15 | | | | |
| | BOTH | 18 | 22 | 30 | | | | |

TABLE 1 (Continued)

| | | YEARS IN VOCATIONAL/ TECHNICAL EDUCATION | | | | ADJUSTED MAINTENANCE COST/PUPIL | | | SIZE OF COMMUNITY | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | NONE | ½ - 1 | 1½ - 2 | 2½ - 3 | ≤ $725 | $726-890 | > $890 | LARGE CITY | SUBURBAN | MEDIUM CITY | SMALL CITY/ RURAL |
| SEX | MALE | 49 | 50 | 47 | 46 | 49 | 49 | 49 | 42 | 50 | 48 | 49 |
| | FEMALE | 51 | 49 | 53 | 53 | 50 | 50 | 50 | 57 | 49 | 51 | 50 |
| CAREER ASPIRATION | SEMI-SKILLED,ETC. | 9 | 8 | 7 | 7 | 11 | 8 | 7 | 6 | 6 | 7 | 9 |
| | SKILLED | 25 | 29 | 33 | 38 | 33 | 31 | 28 | 31 | 25 | 25 | 32 |
| | PROFESSIONAL,ETC. | 53 | 53 | 51 | 46 | 46 | 49 | 54 | 52 | 56 | 55 | 47 |
| ATTITUDE TOWARDS MATHEMATICS | DISLIKE IT | 14 | 12 | 10 | 13 | 13 | 13 | 12 | 10 | 13 | 10 | 12 |
| | IT'S O.K. | 41 | 42 | 42 | 39 | 45 | 42 | 39 | 40 | 38 | 37 | 44 |
| | LIKE IT | 46 | 46 | 48 | 48 | 42 | 45 | 48 | 49 | 48 | 52 | 44 |
| YEARS IN MATHEMATICS | NONE | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| | ½ - 1 | 17 | 17 | 14 | 11 | 20 | 17 | 14 | 11 | 11 | 14 | 20 |
| | 1½ - 2 | 36 | 36 | 39 | 39 | 40 | 38 | 33 | 35 | 36 | 37 | 37 |
| | 2½ - 3 | 35 | 35 | 35 | 36 | 30 | 33 | 38 | 38 | 38 | 35 | 31 |
| | 3½ or more | 11 | 11 | 12 | 14 | 9 | 10 | 13 | 14 | 12 | 12 | 10 |
| YEARS IN VOCATIONAL/ TECHNICAL EDUCATION | NONE | | | | | 30 | 35 | 43 | 35 | 51 | 32 | 30 |
| | ½ - 1 | | | | | 30 | 27 | 25 | 29 | 22 | 29 | 29 |
| | 1½ - 2 | | | | | 25 | 24 | 21 | 26 | 18 | 23 | 26 |
| | 2½ - 3 | | | | | 14 | 12 | 9 | 9 | 7 | 15 | 14 |
| ADJUSTED MAINTENANCE COST/PUPIL | ≤ $725 | 11 | 15 | 15 | 17 | | | | 0 | 0 | 0 | 29 |
| | $726-890 | 39 | 41 | 44 | 45 | | | | 0 | 45 | 24 | 56 |
| | > $890 | 41 | 34 | 33 | 30 | | | | 75 | 49 | 58 | 12 |
| SIZE OF COMMUNITY | LARGE CITY | 13 | 15 | 16 | 11 | 0 | 0 | 29 | | | | |
| | SUBURBAN | 42 | 26 | 24 | 20 | 0 | 33 | 42 | | | | |
| | MEDIUM CITY | 7 | 9 | 9 | 11 | 0 | 5 | 14 | | | | |
| | SMALL CITY/RURAL | 37 | 49 | 51 | 57 | 99 | 62 | 15 | | | | |
| PUPIL SOCIO-ECON-OMIC STATUS | LOW | 19 | 20 | 20 | 21 | 27 | 21 | 18 | 21 | 13 | 17 | 25 |
| | MIDDLE | 54 | 57 | 61 | 64 | 60 | 61 | 53 | 54 | 55 | 55 | 60 |
| | HIGH | 26 | 22 | 18 | 16 | 13 | 17 | 28 | 24 | 31 | 27 | 14 |
| USE OF CALCULATOR OR COMPUTER | NEITHER | 39 | 39 | 38 | 39 | 38 | 38 | 39 | 44 | 35 | 44 | 40 |
| | CALCULATOR ONLY | 24 | 25 | 25 | 26 | 27 | 26 | 22 | 16 | 19 | 30 | 30 |
| | COMPUTER ONLY | 14 | 14 | 12 | 13 | 10 | 13 | 14 | 19 | 18 | 7 | 9 |
| | BOTH | 23 | 23 | 25 | 23 | 25 | 23 | 25 | 22 | 28 | 19 | 21 |

Vocational education students are distributed geographically in a somewhat different pattern than are students with no vocational education; the latter tend to be predominantly from suburban schools (42 percent), although there are also large numbers in small city and rural schools (37 percent). The majority of the former are from small city and rural schools (57 percent). Large and medium city schools have approximately equal representation among non-vocational education and vocational education students. Students at all levels of vocational education are distributed by socioeconomic status in approximately the same form, although a lower percentage of students with one and one-half or more years of vocational education are from the highest SES level than students with one year or less of vocational education.

From an administrative standpoint, it should also be noted that students with higher numbers of vocational education courses are related to slightly lower adjusted maintenance costs per pupil; where as 41 percent of students with no vocational education fall in the highest cost category ($890), the percentage declines with number of vocational education courses, to 30 percent for those with 2½-3 years of vocational education.

Lastly, the distribution of vocational education students by program is shown in Tables 2 and 3. A qualification

should be placed on the interpretation of the large number indicating participation in vocational health programs; the questionnaire item was apparently construed as "health and physical education," a required part of the curriculum for many. With this exception, the largest participation appears to be in

1. business and office,
2. home economics and
3. trade and industrial programs.

For all programs, the numbers of students taking one or two courses is several times that of students taking more courses.

## 2. Attitudes

Attitudes toward mathematics may be investigated in several ways; most directly, students were queried regarding their attitudes. Approximately half of the students with no vocational education express liking of mathematics, and this percentage remains stable with increasing number of vocational education courses. Further, the proportion of students indicating they disliked mathematics was similar for no vocational education (14 percent) and the highest amounts of vocational education (13 percent).

As attitudes toward mathematics appear to be highly related to the number of mathematics courses taken (without speculating as to the direction of causality), number of mathematics courses taken may also be inspected. Again, the distributions for years in mathematics are nearly identical at different levels of vocational education. If there is any perceptible change, it is that fewer students with the largest amounts of vocational education have had little or no (one year or less) high school mathematics (11 percent of these students) versus 18 percent of students with no vocational education.

Finally, we may inquire as to whether some aspects of the mathematical education of vocational education students differ from that of nonvocational education students; a question reflecting one possible difference is experience with computers or calculators. There are no differences among students at different levels of vocational education in such experiences. The critical variable for calculator/computer use appears to be community size.

TABLE 2

AVERAGE (MEAN) PERCENT CORRECT FOR VOCATIONAL/TECHNICAL STUDENTS

1975

| Program Area | Number of Vocational/Technical Courses in Area (Grades10-12) | | | | | |
|---|---|---|---|---|---|---|
| | One or Two | | Three or Four | | Five or More | |
| | Performance | N | Performance | N | Performance | N |
| Agri-Business | 49.6% | 1485 (.10) | 50.6% | 406 (.03) | 43.4% | 159 (.01) |
| Marketing and Distribution | 49.6% | 1407 (.09) | 44.5% | 133 (.01) | — | 16 ** |
| Health | 53.9% | 7639 (.49) | 47.4% | 515 (.03) | — | 77 ** |
| Home Economics | 51.5% | 4306 (.28) | 46.2% | 1440 (.09) | 43.4% | 362 (.02) |
| Business and Office | 54.5% | 5408 (.35) | 51.1% | 1320 (.09) | 49.3% | 481 (.03) |
| Technical | 55.6% | 1610 (.10) | 55.8% | 333 (.02) | — | 90 ** |
| Trade and Industrial | 52.2% | 2625 (.11) | 52.6% | 924 (.06) | 48.8% | 480 (.03) |

This based on a sample of approximately 16,000 17-year-old students across the state.

STATEWIDE PERFORMANCE OF ALL 17-YEAR-OLDS WAS 53.0%.

** Number of students in this category is less than 1% of sample.

TABLE 3

NUMBER OF STUDENTS IN VOCATIONAL/TECHNICAL CLASSES
1975

| PROGRAM AREA | | NUMBER OF COURSES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | NONE | | 1 OR 2 | | 3 OR 4 | | 5 OR MORE | | NO RESPONSE |
| | | NUMBER | PERCENT* | NUMBER | PERCENT* | NUMBER | PERCENT* | NUMBER | PERCENT* | NUMBER |
| AGRI-BUSINESS | MALE | 5861 | 45% | 964 | 65% | 343 | 85% | 131 | 83% | 196 |
| | FEMALE | 7138 | 55 | 506 | 34 | 56 | 14 | 28 | 18 | |
| MARKETING & DISTRIBUTION | MALE | 6576 | 48 | 642 | 46 | 65 | 49 | 9 | 56 | 218 |
| | FEMALE | 6886 | 51 | 753 | 54 | 68 | 51 | 7 | 44 | |
| HEALTH | MALE | 3830 | 56 | 3204 | 42 | 218 | 42 | 43 | 57 | 221 |
| | FEMALE | 3002 | 44 | 4377 | 57 | 294 | 57 | 33 | 43 | |
| HOME ECONOMICS | MALE | 4897 | 60 | 1452 | 20 | 125 | 9 | 16 | 6 | 217 |
| | FEMALE | 3262 | 40 | 5622 | 79 | 1299 | 90 | 246 | 94 | |
| BUSINESS & OFFICE | MALE | 5083 | 65 | 1903 | 35 | 257 | 19 | 42 | 9 | 244 |
| | FEMALE | 2741 | 35 | 3492 | 64 | 1046 | 79 | 440 | 91 | |
| TECHNICAL | MALE | 5703 | 44 | 1222 | 76 | 280 | 84 | 84 | 93 | 219 |
| | FEMALE | 7282 | 56 | 375 | 23 | 50 | 15 | 6 | 7 | |
| TRADE & INDUSTRIAL | MALE | 4030 | 36 | 1953 | 74 | 850 | 92 | 455 | 94 | 222 |
| | FEMALE | 6977 | 63 | 652 | 25 | 64 | 7 | 20 | 4 | |

* Percentages do not always total 100 due to non responses.

3. Mathematics Achievement

The crucial questions to be asked here were:

1. how do students at varying levels of vocational education perform;

2. were there differences in performance as a function of type of program and

3. were there different patterns of achievement within the mathematics assessment for vocational education and nonvocational education students.

(a) Overall performance: As indicated by the following display, the comparisons of total mathematics performance for vocational and nonvocational students was not conclusive.

Number of Years in Vocational-Technical Courses

| | Mean Percent Correct |
|---|---|
| None | 52.3% |
| ½ to 1 year | 53.3 |
| 1½ to 2 years | 53.9 |
| 2½ to 3 years | 53.6 |

(b) Performance by Program Area: Mean performance by students in various vocational education programs does not appear to differ significantly from the state-wide mean of 53.0 percent, particularly with lower numbers of vocational

education courses taken. Students in agribusiness and marketing/distribution programs scored slightly below the mean (49.6 percent) while students in business and office and technical programs scored slightly above the mean (54.5 percent and 55.6 percent, respectively). Some interaction between type of program and number of courses taken may, however, occur. The achievement of home economics students with 3-4 courses declines to 46.2 percent, and to 43.4 percent with five or more courses. The effect of amount of vocational education is explored below.

(c) Number of Vocational Education Courses: While there is some suggestions that performance may decline in some vocational programs with increased numbers of courses, a more detailed analysis in terms of clusters of items and particular objectives suggests that with increasing numbers of vocational education courses, there may be a decline in certain areas of mathematics achievement but an increase in others. Tables 4 and 5 indicate achievement on each cluster at various levels of vocational education (see Appendix 2 for description of clusters) and Table 6 provides the same type of analysis at the level of specific objectives. The objectives are described in Appendix 3.

Summarizing these analysis, it appears that there are areas of mathematics in which students with no vocational education perform better (quadratics; graphing functions; finding the equation of a graph) and related areas in which students with

the most vocational education perform significantly below the state mean (knowledge of trigonometric terms, identifying a graph of a function, solving simultaneous equations, expanding binomials, and finding equation of a graph). However, on a set of objectives which can be characterized as practical applications of mathematical skills, students with the most vocational education courses scored significantly better than the group as a whole. Included in this set were knowledge of basic operations, computational skills, interpolating and extrapolating from a table, solving verbal problems, applying formulas, and comparative buying. The objectives are summarized in Table 7 and suggest that vocational education students, though they may be exposed to fewer higher level mathematical concepts, are proficient in making proctical application of their mathematical skills.

TABLE 4

SEVENTEEN-YEAR-OLD MATHEMATICS PERFORMANCE ON CLUSTERS
GROUPED BY
TYPE OF VOCATIONAL-TECHNICAL CLASSES

| Math Cluster[α] | Statewide Performance* | Agri.-Business | | Mkt.-Dist. | | Health | | Home Ec. | | Bus. & Off. | | Technical | | Trade & Ind. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1-2 | 3+ | 1-2 | 3+ | 1-2 | 3+ | 1-2 | 3+ | 1-2 | 3+ | 1-2 | 3+ | 1-2 | 3+ |
| C1 | 91.8 | 91.5 | 90.0 | 91.1 | 91.4 | 92.2 | 90.8 | 92.3 | 90.5 | 93.1 | 93.6 | 91.2 | 89.8 | 91.0 | 89.7 |
| C2 | 61.3 | 57.9 | 60.4 | 55.3 | 48.3 | 61.8 | 55.1 | 58.5 | 50.9 | 62.2 | 58.4 | 66.4 | 63.3 | 61.0 | 62.9 |
| C3 | 51.8 | 48.8 | 49.9 | 48.3 | 44.4 | 52.3 | 44.2 | 49.7 | 43.2 | 54.5 | 55.4 | 55.2 | 51.1 | 51.3 | 47.3 |
| P1 | 61.5 | 55.8 | 55.2 | 56.6 | 48.7 | 62.9 | 55.1 | 59.5 | 52.6 | 62.7 | 59.0 | 62.5 | 65.1 | 59.8 | 58.3 |
| B1 | 61.6 | 57.1 | 56.9 | 57.5 | 52.6 | 62.5 | 55.6 | 59.5 | 53.9 | 63.0 | 57.4 | 64.3 | 65.3 | 60.7 | 61.2 |
| G2 | 52.5 | 48.4 | 51.6 | 47.8 | 41.9 | 53.0 | 47.6 | 49.9 | 41.7 | 52.7 | 47.7 | 56.7 | 57.5 | 52.8 | 55.2 |
| A1 | 49.4 | 46.1 | 45.2 | 46.0 | 36.8 | 52.6 | 45.0 | 49.9 | 42.0 | 53.8 | 47.6 | 53.5 | 54.3 | 48.9 | 46.9 |
| A2 | 35.2 | 31.2 | 30.4 | 31.9 | 24.7 | 35.9 | 30.7 | 33.2 | 28.1 | 36.5 | 31.4 | 37.6 | 36.9 | 33.4 | 32.3 |
| I1 | 51.4 | 48.8 | 49.4 | 48.9 | 41.0 | 52.0 | 45.8 | 49.4 | 42.9 | 52.2 | 48.5 | 54.0 | 55.3 | 50.9 | 51.4 |
| PS1 | 63.4 | 62.4 | 62.6 | 60.5 | 56.0 | 63.8 | 56.0 | 61.1 | 54.8 | 64.9 | 62.8 | 67.4 | 64.9 | 64.0 | 64.3 |
| PS2 | 44.8 | 40.0 | 40.9 | 40.0 | 36.1 | 44.5 | 38.2 | 42.5 | 37.8 | 45.2 | 41.6 | 45.1 | 46.1 | 42.7 | 40.0 |
| M1 | 58.4 | 73.4 | 73.5 | 69.0 | 60.9 | 74.7 | 69.6 | 72.5 | 63.1 | 74.6 | 68.6 | 82.3 | 78.7 | 76.8 | 77.3 |
| SP | 25.1 | 23.2 | 24.3 | 24.4 | 19.4 | 25.8 | 16.7 | 23.6 | 21.3 | 25.7 | 23.0 | 26.8 | 24.8 | 24.4 | 22.3 |
| S1 | 70.9 | 64.9 | 65.1 | 66.4 | 66.7 | 72.3 | 60.9 | 69.4 | 66.5 | 74.2 | 71.2 | 71.9 | 70.6 | 70.1 | 65.4 |
| T1 | 17.1 | 18.3 | 16.9 | 14.4 | 15.1 | 19.9 | 17.2 | 17.9 | 16.4 | 19.9 | 14.9 | 22.6 | 20.8 | 19.0 | 17.4 |

*Indicates the average percent of items correct for Minnesota 17-year-olds.

α See appendix for description of clusters.

TABLE 5
NUMBER OF YEARS IN VOCATIONAL/TECHNICAL COURSES (10-12)

| Cluster (Number of Items) | Description | PERCENT CORRECT Number of Years in Vocational/Technical (10-12) | | | | Comment |
|---|---|---|---|---|---|---|
| | | None | ½ - 1 | 1½ - 2 | 2½ - 3 | |
| C1 (12) | Computation with whole numbers | 91.4 | 91.9 | 92.6* | 92.8* | More voc/tech significantly above state mean |
| C2 (10) | Concepts and computation with common fractions | 60.0* | 61.0 | 63.1* | 64.4* | Less voc/tech < more voc/tech |
| C3 ( 9) | Concepts and computations with decimal numbers | 50.3* | 51.2 | 54.2 | 55.5* | Less voc/tech < more voc/tech |
| P1 (12) | Properties of numbers | 61.1 | 60.9 | 62.8* | 62.3 | |
| G1 (21) | Recognition of geometric properties | 61.1 | 62.7* | 62.3 | 61.4 | |
| G2 (18) | Applications of geometric properties | 51.9 | 52.0 | 53.6 | 54.8* | Most voc/tech significantly above state mean |
| A1 (25) | Algebraic expressions | 49.0 | 50.0 | 50.6* | 48.5 | |
| A2 (27) | Algebraic applications | 34.8 | 36.3* | 35.2 | 34.5 | |
| I1 (14) | Interpret graphs, tables and maps | 50.9 | 51.8 | 51.7 | 52.7 | |
| PS1 (16) | Basic problem solving | 62.1* | 62.9 | 65.3* | 66.6* | Less voc/tech < more voc/tech |
| PS2 (40) | Advanced problem solving | 44.1* | 45.4 | 45.4 | 45.4 | No voc/tech significantly below state mean |
| M1 ( 9) | Measurement systems | 58.1 | 59.3 | 58.0 | 58.5 | |
| SP ( 6) | Statistics and probability | 25.1 | 25.7 | 24.5 | 25.3 | |
| S1 ( 3) | Sets | 69.7 | 70.8 | 73.2* | 72.1 | |
| T1 ( 5) | Trigonometry | 19.7 | 21.0 | 19.9 | 16.8* | Most voc/tech significantly below state mean |

## TABLE 6

OBJECTIVE ANALYSIS 17-YEAR-OLD MATHEMATICS ASSESSMENT

| Objective (number of items) | | Description | Number of Years in Vocational/Technical (10-12) (Percent Correct) None (N=3533) | ½ - 1 (N=2852) | 1½ - 2 (N=2466) | 2½ - 3 (N=1303) | Comment |
|---|---|---|---|---|---|---|---|
| IA1 | (3) | Knowledge of basic add.,sub., mult. and div. | 95.8%* | 97.1% | 97.2% | 97.4% | Less voc/tech<more voc/ tech |
| IA2 | (5) | Knowledge of percent and ratio | 40.8 | 40.1 | 43.2 | 44.7* | |
| IC3 | (4) | Knowledge of f(x), log x, exp x, exponential notation, cartesian pairs | 46.8 | 47.5 | 46.9 | 45.8 | |
| IE1 | (7) | Knowledge of terms: variable, coordinate, etc. | 61.7 | 63.6 | 63.4 | 62.1 | |
| IE2 | (2) | Knowledge of terms: functions, inverse | 38.0 | 39.8 | 40.9 | 39.1 | |
| IF1 | (7) | Knowledge of terms: parallel, similar, ray, etc. | 75.9* | 78.3* | 78.2 | 77.0 | |
| IF2 | (4) | Knowledge of figures: circles, polygons, etc. | 88.3 | 89.2 | 91.3* | 90.2 | |
| IG1 | (1) | Knowledge of terms: elem. analytic geometry, slope, etc. | 57.1 | 55.5 | 57.0 | 53.6 | |
| IG2 | (3) | Knowledge of terms: trig. - sine, cosine, rt. triangle, etc. | 21.4 | 22.4 | 21.4 | 16.5* | Most voc/tech significantly below state mean |
| I I | (3) | Knowledge of trig. functions: 30-60-90 tri., 45-45-90 tri. | 22.8 | 25.4* | 23.5 | 24.3 | |
| I J | (3) | Knowledge of geometric facts | 37.9 | 38.4 | 35.5 | 36.5 | |
| I K | (3) | Laws for exponents and logs | 40.9 | 40.9 | 43.0* | 38.7 | |
| I L2 | (3) | Identify graphs: parabola, hyperbola, ellipse | 38.1 | 38.8 | 35.0 | 32.2* | Most voc/tech significantly below state mean |
| I Q | (1) | Scientific notation | 71.1 | 67.6* | 74.4* | 73.6 | |
| I R | (6) | Metric System | 71.1 | 72.2 | 71.3 | 71.6 | |
| I S | (1) | Nec. and suff. conditions, inverse, etc. | 48.4* | 52.4 | 51.9 | 57.4* | Less voc/tech<more voc/ tech |
| IIA | (15) | Computation with approximate data | 78.4* | 79.5 | 81.8* | 82.1* | Less voc/tech<more voc/ tech |
| IIB | (8) | Manipulation of algebraic expressions (1st degree polynominals) | 45.3 | 45.8 | 46.2 | 45.2 | |
| II G | (2) | Conversion relations in measurement | 30.1 | 30.7 | 29.3 | 29.7 | |
| IIJ1 | (2) | Solving simultaneous (linear) equations | 13.6 | 13.5 | 12.0 | 9.2* | Most voc/tech significantly below state mean |
| IIJ2 | (1) | Solving simultaneous (linear and quad) equations | 11.3* | 15.9 | 16.9* | 12.3 | Less voc/tech<more voc/ tech |
| II N | (3) | Interpolation and extrapolation with table | 55.2 | 54.5 | 54.9 | 58.2* | Most voc/tech significantly above state mean |
| IIP | (1) | Synthetic division | 5.1 | 3.1* | 5.6 | 3.1 | |
| IIQ | (2) | Expanding a binomial | 29.9 | 30.2 | 30.3 | 26.1* | Most voc/tech significantly below state mean. |
| IIR | (1) | Reading graphs | 91.8 | 93.2 | 94.3 | 93.8 | |
| IIS | (3) | Using formulas | 74.6* | 75.5 | 78.2* | 79.2* | Less voc/tech<more voc/ tech |

* Indicates significant difference ($p \leq .05$) from state percentage correct for objective.

Table 6 (Continued)

OBJECTIVE ANALYSIS 17-YEAR-OLD MATHEMATICS

| Objective (Number of Items) | | Description | Number of Years in Vocational/Technical (10-12) (Percent Correct) None | ½ - 1 | 1½ - 2 | 2½ - 3 | Comment |
|---|---|---|---|---|---|---|---|
| IIT1 | (8) | Solve equations and inequalities in one variable | 47.0* | 48.8 | 48.8 | 47.6 | Less voc/tech significantly below state mean |
| IIT2 | (5) | Solve equations and inequalities (quad) | 23.4 | 26.3* | 23.2 | 21.4* | Less voc/tech > more voc/tech |
| IIIA1 | (2) | Make a graph of a function (linear) | 42.8 | 43.8 | 42.8 | 46.0 | |
| IIIA2 | (4) | Make a graph of a function (quad and higher) | 23.0 | 25.0* | 23.3 | 19.7* | Less voc/tech>more voc/tech |
| IIIB1 | (2) | Finding equation of graph (linear) | 19.6 | 19.5 | 17.7 | 15.4* | Most voc/tech significantly below state mean |
| IIIB2 | (1) | Finding equation of graph (quad and higher) | 6.6 | 8.2* | 4.6* | 2.3* | Less voc/tech>more voc/tech |
| IIIJ | (4) | Interp. stat. data: mean, mode, mdn. etc. | 19.5 | 20.8 | 19.8 | 20.1 | |
| IIIK | (5) | Translating verbal to math sentence | 56.9 | 57.5 | 58.7 | 60.8* | Most voc/tech significantly above state mean |
| IIIL | (1) | Illustrating geom. theorem by making sketch | 57.0 | 54.1 | 55.9 | 55.0 | |
| IVA | (1) | Solution of triangles using trig. ratios | 11.3 | 13.3 | 12.2 | 10.5 | |
| IVC1 | (3) | Solving verbal probs. (simple linear, one variable) | 42.9 | 44.9 | 44.9 | 47.7* | Most voc/tech significantly above state mean |
| IVC3 | (3) | Solving verbal probs. (2 or more var., 2nd degree equation) | 24.0 | 23.8 | 23.9 | 23.0 | |
| IVE | (2) | Interp. tables & graphs | 69.8 | 71.7 | 70.2 | 74.2* | Most voc/tech significantly above state mean |
| IVF | (6) | Applying formulas | 55.7* | 56.1 | 59.8* | 59.8* | Less voc/tech<more voc/tech |
| IVH | (3) | Computing with complex numbers | 33.2 | 34.3 | 34.5 | 30.7 | |
| IVL | (1) | Locating a flaw in geom. proof | 22.9 | 22.4 | 20.9 | 20.8 | |
| IVM | (1) | Locating a flaw in algebraic proof | 12.9 | 10.9 | 10.6 | 11.7 | |
| IVR | (1) | Solving shop problems | 18.4 | 17.0 | 20.5 | 19.6 | |
| IVU | (2) | Estimation | 56.3* | 59.3 | 58.8 | 60.0 | No voc/tech significantly below state mean |
| IVV | (1) | Translation of problem into flow chart | 41.8* | 48.0 | 45.1 | 46.5 | |
| IVW | (4) | Solve consumer problems: tax, ins., etc. | 61.3* | 62.0 | 64.8* | 66.5* | Less voc/tech<more voc/tech |
| VA | (2) | Geometric experiments | 49.3 | 51.0 | 51.5 | 52.7 | |
| VB | (3) | Patterns & generalizations about configurations | 60.4 | 60.8 | 62.3 | 62.6 | |
| VC | (6) | Solving novel probs., puzzles | 38.8* | 41.0 | 41.3 | 41.4 | No voc/tech significantly below state mean |
| VD | (2) | Comparative buying | 49.9* | 52.3 | 53.1 | 55.6* | Less voc/tech<more voc/tech |
| VF | (1) | Budgeting | 29.5 | 30.5 | 30.9 | 33.4 | |
| VH | (1) | Discover fallacies in consumer ad | 53.7 | 53.5 | 55.5 | 52.4 | |
| VP1 | (2) | Prob. solv.: counter examples | 49.0* | 51.5 | 51.5 | 52.8 | No voc/tech significantly below state mean |
| VP2 | (2) | Problem solving: use of similar case | 35.7 | 33.7 | 35.8 | 36.9 | |
| VP3 | (2) | Prob. Solv.: Looking at extremes | 51.1 | 51.7 | 53.7 | 50.6 | |
| VP4 | (2) | Prob. Solv.: Assume answer known | 51.8 | 52.7 | 52.7 | 51.9 | |
| VP5 | (5) | Prob. solv.: Analysis of problems | 67.4 | 68.2 | 68.1 | 68.2 | |

TABLE 7

SUMMARY OF FINDINGS

| Objectives on which students with NO voc/tech, or the least voc/tech performed significantly better than the group as a whole | Objectives on which students with more or the most voc/tech performed significantly better than group as whole |
|---|---|
| IIT2 - Solving equations and inequalities of quadratics<br>IIIA2 - Make a graph of a function (quadratic and higher)<br>IIIB2 - Finding equation of graph (quadratic and higher) | IA1 - Knowledge of basic add., sub., mult., and div.<br>IS - Necessary and sufficient conditions, inverse, etc.<br>IIA - Computation with approximate data<br>IIJ2 - Solving simultaneous (linear and quad.) equations<br>IIN - Interpolating and extrapoling with table<br>IIS - Using formulas |
| Objectives on which students with the most voc/tech were significantly below the group mean | IIIK - Translating verbal to mathematical statement<br>IVC1 - Solving verbal problems; simple linear with one variable<br>IVE - Interpreting tables and graphs<br>IVF - Applying formulas<br>IVW - Solving consumer problems<br>VD - Comparative buying |
| IG2 - Knowledge of trig terms<br>IL2 - Identify graph of functions<br>IIJ1 - Solving simultaneous linear equations<br>IIQ - Expanding a binomial<br>IIIB1 - Finding equation of a graph (linear) | |

E. Evaluation: The present study has attempted to determine the characteristics of students served by vocational education programs, their attitudes toward mathematics, and their mathematical achievement. In terms of the information provided by the MEAP instruments and survey data, it has been possible to determine that vocational education students

1. excel in some practical applications of mathematical knowledge,
2. show slightly lower performance in advanced theoretical areas, and
3. their attitudes toward mathematics are not substantially different from those of students who have not participated or participated less in vocational education courses.

Suggestion of limitations and further design refinements are made below.

F. Conclusions, implications and recommendations: The major conclusions of this study may be summarized as follows:

1. Vocational education students are similar in many demographic characteristics to nonvocational education students; the major differences are that vocational education represent small city and rural schools to a greater extent, underrepresent the highest SES level, and tend to be related to slightly lower adjusted maintenance costs per pupil.

2. Vocational educational students show the same distribution of attitudes towards mathematics as nonvocational education students, and have taken equivalent numbers of mathematics courses as the general high school population.

3. Vocational education students do not significantly differ from nonvocational education students in overall mathematics achievement; they may, however, perform better in terms of practical applications of mathematical skills and slightly below the overall mean in more advanced and/or theoretical mathematical concepts.

The implications of these findings seem similarly straightforward:

1. Vocational education is not significantly related to attitudes toward, participation in, or benefit from mathematics courses in terms of either boosting or depressing performance on the measures used here. On general measures, the distribution of vocational education and nonvocational education students do not differ significantly.

2. If there are differences in mathematics achievement, they appear at the level of particular objectives and indicate the relative success of vocational education programs: the vocational

education students performed significantly better in terms of practical applications of mathematics and "real-world" skills.

The major recommendation to be made following this study is that the ad hoc nature of the objectives analysis should be corrected: vocational educators should be encouraged to formulate mathematics objectives in which their students are trained, such that a specific prediction of achievement differences might be tested.

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